The introduction of a maintenance expert system into an industrial context: the case of the P.A.M container terminal of Fos-Commerce

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YORIA 87'

PROGRAMME

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INSTITUT INTERNATIONAL DE ROBOTIQUE
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PROGRAMME

Jeudi 18 juin 1987
Thursday 18 june 1987

08h.30 - 09h.00 Accueil des participants
Members reception

09h.00 - 09h.30 Discours de bienvenue
Welcome speech
Jean-François LE MAITRE, Directeur Général IIRIAM

SESSION 1/Président de session : Vieillard BARON, Directeur Général IRCN

09h.30 - 10h.00 Jean-Claude RAULT, EC2, France.

Etat de l'Art sur l'utilisation des systèmes experts.
State of the Art of expert systems applications.

10h.00 - 10h.30 M.-F. MAC GOWAN, Cooperative Institute for Marine and Atmospheric Studies, Miami, USA.

Catcurv1, un système expert de contrôle de ferme aquacole
Catcurv1, a fishery management expert system module

10h.30 - 11h.00 Pause
Break

SESSION 2/Président de session : Jean-Claude RAULT, Directeur Général EC2

11h.00 - 11h.30 M. ALQUIER, ENSEEIHT, France

Routage de navires de courses à voile.
Artificial Intelligence and Navigation in sail boat races.

11h.30 - 12h.00 J. SCHOELLKOPF, S2O Développement, France

PNAO, un système expert d'aide à la navigation
PNAO, an expert system for offshore positionning and navigation.

12h.00 - 12h.30 J. FOX, University of Hawaii, USA

Le laser dans la vision artificielle des robots sous-marins.
Laser aided machine vision in the ocean.

12h.30 - 14h.00 Déjeuner
Lunch

SESSION 3/Président de session : Georges THEBAUD, Comité Central des Armateurs de France.

14h.00 - 14h.30 J.P. POITOU, CNRS, France

L'expert et le système, conséquence pour l'analyse cognitive ; exemple en construction navale.
The expert and the system, consequence for cognitive analysis ; exemple in naval shipbuilding.

14h.30 - 15h.00 M. Daniel, Ecole Nat. Sup. Mécanique, France
JM KOBUS ; C. SAYETTAT.

Les techniques de l'Intelligence Artificielle appliquées à la CAO de bateaux de pêche.
Artificial Intelligence technics in CAD for fishing boats.

15h.00 - 15h.30 B. BARET, Institut de Recherches de la Construction Navale, France
M. CAYROL ; J. LAFORGUE ; D. MARS

Utilisation de l'intelligence artificielle en CAO : une évolution vers une deuxième génération de CAO pour le traitement de la structure métallique d'un navire.
Use of Artificial Intelligence in CAD : CAD Evolution for the Steel Hull Design in Shipbuilding Industry.

15h.30 - 16h.00 Pause
Break

SESSION 4/Président de session : Pierre ORSERO, IMT, Directeur de l'Ecole Supérieure d'Ingénieurs, Marseille.

16h.00 - 16h.30 J.-M. ANDRE, Laboratoire de Marcoussis, France

CADOO, un système expert en aménagement spatial de compartiment machine de navire.
CADOO, an expert system in spatial accomodations.

16h.30 - 17h.00 B. NEVEU, INRIA, France

SMECI, un système expert de conception de digues portuaires.
SMECI, an expert system for breakwater conception.

18h.00 - 19h.30 Cocktail à l'hôtel de Ville de Marseille
Cocktail at the City Hall of Marseilles.

Vendredi 19 juin 1987
Friday 19 june 1987

SESSION 5/Président de session : Hubert Du MESNIL, Directeur de l'Exploitation, Port Autonome, Marseille.

09h.30 - 10h.00 R. BALEYDIER, Port Autonome de Marseille, France
N. FABBES COSTES

Système expert de diagnostic de maintenance de porte conteneur.
Expert system of maintenance diagnostic for handling container machine.

10h.00 - 10h.30 D. PEGUIN, CEFI, France
J.P. DAUBIGNEY, D. PICHERAL, J.-L. FUGUET, A. ROUX

Système expert pour la prévision à long terme des trafics portuaires.
Expert system for long term harbour traffic prevision.

10h.30 - 11h.00 Pause
Break

SESSION 6/Président de session : J.-P. FAIL, Institut Français du Pétrole (IFP)

11h.00 - 11h.30 B. HAMIDI, R. TREMOLLIERES, IAE, France
J.-L. MONTELLY, B. CARPENTIER

Système expert d'information et de décision en gestion portuaire.
Information and decision expert system in harbour management.

INTRODUCTION OF A MAINTENANCE EXPERT SYSTEM

INTO AN INDUSTRIAL CONTEXT

THE CASE OF THE P.A.M. CONTAINER TERMINAL OF

FOS-COMMERCE

LECTURERS :

R. BALEYDIER	Maintenance Manager Port Authority of MARSEILLE-FOS
N. FABBE-COSTES	Research Advisor Port Authority of MARSEILLE-FOS Searcher C.R.E.T. AIX-MARSEILLE 2 University
D. COLLAS	Project Manager S2O Informatique MARSEILLE

Communication au colloque ORIA'87 "ARTIFICIAL INTELLIGENCE AND SEA", 18-19 juin 1987 à MARSEILLE.

I - THE CONTEXT OF THE PLAN.

I.I. SPECIFIC FUNCTIONS OF PORT ACTIVITIES.

I.2. FEATURES OF PORT MAINTENANCE.

I.3. COMPUTER TOOLS IN MAINTENANCE OF PAM-FOS.
MAINTENANCE - ORIENTED COMPUTER SYSTEMS.

I.4. SOME SIGNIFICANT STATISTICS.

II - DIAGNOSIS AND MAINTENANCE AID SYSTEM.

II.I. THE AIMS OF THE SYSTEM.

II.2. TECHNICAL FEATURES.

II.3. THE ORGANISATION AND EXECUTION OF THE PLAN.

II.4. THE STAGES OF DEVELOPMENT.

III - CONCLUSION.

THE INTRODUCTION OF A MAINTENANCE EXPERT SYSTEM INTO AN INDUSTRIAL CONTEXT.

THE CASE OF THE PAM CONTAINER TERMINAL OF FOS COMMERCE.

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I - THE CONTEXT.

At a time when the container shipper operators disassociate their container activities from those of running a fleet, when container logistics stress the quality of the service of the different links in the chain, while, at the same time, insisting on efficiency, the ports, competing to comply with increasingly demanding requirements, must meet this challenge which is more of a technical and organisational than of a commercial nature.

This challenge facing the ports, in the dual framework of ther functions as a sea-board relay and a land-sea interface, is to provide ther customers with all the means of handling their containers in compliance with the latest traffic standards.

As well as co-ordinating the port functions and the services attached to its infrastructures, the port of Marseille Authority has the responsability of providing its customers with an overall service, which is to hire quai-side unloading cranes in working order, complete with teams to drive them and technical support in case of incidents. The main requirement in order to offer such a service is to set up a structure personnel and technical and organisational means which will both ensure the maintenance of the material when not in use and perform running repairs.

To have a clearer understarding of the requirements and characteristics of port equipment maintenance, we define the specific functions of port actiwities.

I. 1 - SPECIFIC FUNCTIONS OF PORT ACTIVITIES.

The role of the PAM in the port activities of FOS-COMMERCE is to provide a service which must satisfy the customers requirements both quality and cost wise when they are expressed, that is : when the ship arrives.

Thus, ports activities are both discontinuous and irregular, both in volume and time, and moreover they are subject to many impredictable events. Furthermore, the port must be ready to cope with peak demand, particularly when dealing with third or fourth generation container carriers. In such cases, the higher the quality of service required and the greater the importance of the stop over (that is, the number of picks), the more crucial will be the peak.

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In down-to-earth terms, the PAM must provide a sufficient number of readily available, reliable cranes for loading and unloading ships,taking into account the following factors :

- the arrival times (dates) of the ships as well as the reservation (booking) of equipment are subject to contingencies (crane hiring is definitely confirmed at best twelve hours ahead).

- staggering the stop-overs cannot always be arranged despite a stop-over booking system and allocating priority dates. Therefore traffic peaks must be provided for.

- once the handling of a ship has started, it becomes the (N°1) priority.

The maintenance structure which guarantees the quality of the service offered by the PAM, must employ all the means which will enable it to cope with the different requirements and organise its intervention so as to ensure optimum working conditions for the equipment.

I. 2 - FEATURES OF PORT MAINTENANCE.

In its role as supplier of a service, as we have just defin it, the port must have an efficient repair structure ready to intervens during any handling operations, so as to offer maximum maintenance efficiency. A breakdown, should it occur, must have as little effect as possible and so the repairs must be swift and sure.

However, the basic task of a port maintenance department is to ensure the reliability of the equipment provided for the customers by canyingent repairs between ships. The difficulty in achieving this aim lies mainly in the uncertainty about the external factors which would enable the work to be scheduled easily and strictly. On the one hand, between-ship maintenance must fellow up any breakdowns (this work is difficult to foresee), on the other hand,it must schedule preventive and improvement maintenance insofar as co-ordination with handling operations allows.

In view of the high degree of uncertainty concerning both running repairs and between-ship maintenance, only the control information, ideally in real time and the setting up of décision, aid systems can enable a port maintenance structure to reach the quality and cost targets of its mission.

To do so, the Management of the FOS installations, within the framework of its technical equipment management at FOS, has undertaken a plan to develop and use computer systems concerning the maintenance in the widest sense of the term) of handling equipment.

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The expert system presented here stems from this growing drive towards innovation in the technical and organisation fields. In order to understand the aim of this system and, insofar as it fits in with the systems already installed, we shall ontline rapidly the situation as it stands.

I. 3 - MAINTENANCE ORIENTED COMPUTER SYSTEMS.

The use of computers in maintenance at FOS develops around four poles, corresponding to distinct, but complementary functionalities.

The first pole concerns co-ordination with the operations Department.(Exploitation (ship handling) department). By consulting the TPE system (stop-over Forecastingand Processing), we can envisage planning our maintenance actions according to traffic evolution. A co-ordinator performs the actual day-to-day matching of forecasts with maintenance avai abilities.

A second pole is MARGO (Computer Managed, Regulated and Aided Maintenance) which allows both a better technical and financial mastery of the whole of the maintenance work and a more efficient management of the work force available.

This integrated system allows, on the one hand, the foremen to prepare the work and, on the other hand, the team leaders to organise and record ther activities every day. Finthermore, it allows the people in charge to access this information through several fellow up and analysis programmes.

The third pole aims at meeting as closely as possible the specific needs of all the different activities. It is concerned with making available on a self-service basis several standard micro-computer packages, the necessary tools, to help in performing individual personal tasks.

The fourth pole, of which the present plan is part, concerns linking up with the material with a view to more efficient interventi during operations and a better analysis and exploitation of the knowledge of haw the equipment works.

The study, design and implementation of a parameter acquisition system (SAP), is the starting point for this aspect of development. This system carries out the acquisition, processing and transmission of all information concerning materials operations. This information will be analysed by the system which we are going to present.

But, before going any funther, a few figures about the maintenance activity at the FOS-Commerce container terminal.

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I. 4 - SOME SIGNIFICANT STATISTICS.

The traffic :

250 000 picks per year
13 500hours of operations.

Equipment :

7 cranes on 1200 m of quai-side

Cost of a new crane = 25 Million francs

Theoretical crane life = 15 years

Cost of a new spreader = 700 thousand Francs

Theoretical spreader life ≃ 5 to 10 years.

Maintenance :

45000 hours maintenance (internal)

Direct maintenance costs = 7 to 10 percent of the equipments replacement cost.

Maintenance cost per container = 80 F per pic

II - DIAGNOSIS AND MAINTENANCE AID SYSTEM.

II. 1 - THE AIMS OF THE SYSTEM.

The system being developed seeks to reduce intervention time on crane breakdowns and dysfunction.

These interventions, depending on how serious they are, are performed by:

- the driver (simple faults)
- an electrotechnician or a mechanic if necessary (more complex faults which can however be dealt with while running).
- a maintenance team, after withdrawl from operations (for more serious problems).

To do so, the people called in are given the means of acting faster and working better with shorter down-times.

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II. 1. 1. Diagnosis Aid.

1. Aid for the driver.

He must be given the means of repairing by himself simple faults or dysfunctions (fuses, relay resetting, start-up conditions not respected, etc...) through information on the state of the crane (warnings about potential breakdown conditions or information to explain why something is out working).

If, through lack of knowledge or informati the driver cannot do the repairs, a repairman is called in.

2. Aid for the Repairman.

He must be given the information to guide him in his diagnosis. The system does not mak the diagnosis for the repairman, but provides him with efficient ways of tackling the probl In particular, he must be able to decide whether the trouble is electrical or mechanic so as to call in immediately the competent people.

When questioned, the repairman said that their first reaction when called in was to ask the driver about the work underway when the fault occurred.

For example, the repairman learns that the driver was lifting a container at high speed and was taking it towards the quai-side when lifting stepped.

Knowing the context of the fault enables him to make hypotheses about it which he will then try to check out. The advantage of this method is that not all the possible faults have to be checked but only those which fit in with context (load lifting at high speed). After a more detailed analysis of the informat concerning the crane, some of these hypotheses can be abandoned, leaving just a limited numbe

This, diagnosis aid goes through three phases :

- operations monitoring (to detect dysfunction and record the context in which the fault occurred).

- hypothesis generation, repecting those not compatible (current sensor output).

.../...

- making outa diagnosis file, giving :

  . the hypotheses envisaged.
  . the hypotheses rejected (with reason given, on request).
  . the hypotheses to be checked out with the procedure for doing so.

II. 1. 2. - Maintenance Aid.

This is carried out by the follow-up :

- the faults (fault files describing the incidents, then previous occurrences, diagnosis

- the interventions. These have an influenc on the way hypotheses are treated (a component which bras recently been repaired will, of course, be suspect).

- the equipment. This will give a better picture of the components and enable the maintenance to be planned better according to then "case-history".

II. 1. 3. - Improvement Aid.

This necessarily implies a better knowledg of the equipment and comes in the form of mathematical tools which allow a more detailed analysis of the faults (chronological accounts, statistics, correlations).

II - 2 - TECHNICAL FEATURES.

The system is connected to the material, that's to say, it is capable of collecting enormous amounts of information. So in order to minimize instrumentation costs, a choice has been made in this mass of knowledge, simply keeping, sufficiently precise information to enabl economically interesting hypothèses to be generated : information which is functionally important on liable to improve fault detection efficiency.

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The system can link up with maintenance management (two-way exchanges).

Since crane knowledge is not static, in order to generate and check hypotheses, the software should be able to evolve and interact easily (interfaces and explanations).
For these reasons, one chose the expert system approach.

The need to interconnect with separated acquisition software and information storage/retrieval software made us look for a tool easy to interface with and integrate in "software system".

The expert system has been developed from the NEMO tool written in Pascal, which enables :

- to define objects with properties and inherita
- to define links with and actions on the outsid world in the shape of programmes (interfaces).
- to define rules (with variables) which can be forwend chained.
- to deal with non-monotony (possibility of revising conclusions).

II - 3 - THE ORGANISATION AND EXECUTION OF THE PLAN.

II. 3.1. - Development structure.

If this type of system is to be able to evolve, the future users (operating and repair personnel) must take part in elaborating and setting it up. In this way, the functionalities will meet the requirements defined and the repairman will take charge of the further evolution of the system.

The Port participated by housing the plan in its premises from the start of the analysis phase and by setting up a mixed team composed of :

- a computer engineer specialised in A.I.and realtime (S 2 O).
- a plan manager (PAM - FOS).
- a counter-expert responsible for guiding the analysis and for taking final decisions in case of expertise disagreement.
- a team of ten experts with their experience in repairs.

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II. 3. 2. - Problems Encountered.

They concern on the one hand the acceptation by and the motivation of the people on the plan, and on the other hand, the more practical problems of expertis

1) The future users were reticent and worried whe faced with a system which could eventually modify the quality and the content of their work. These reticences were not an obstacle during the development phase but were more so when the plan was started up and will be even more so when it is implemented because of the new constraints it may create.

2) The motivation of the experts is another tricky point. The task of analysing faults is exacting and tiresome and ways must be found to motivate them. We ha used several.

- first, by allowing each of them to deal with the subjects which they are most interested in (hence a multi-expert team).

- by birefing them on the progress of the knowledg collecting (this is the instructive aspect the experts have learnt new things).

- by showing them how their expertise has been used (to validate it).

3) There is a real problem of completeness of the expertise. All the expertise is not necessarily inside the compagny AI in depth study of the diagnosis methods is an opportunity of showing up any short comings in the methods or the means employed bringing these systems to light is the first contribution of the system for in this way methods can be improved and knowledge expanded, if necessary by calling in crane designers.

4) Finally, the availability of the experts is the last difficulty. It's a fact that their primary function is repair-work and it isn't easy to have their released from their jobs at regular times. Thus, question session had to be arranged so as to fit in with their work schedules. The sessions are held at a rate of roughly one session per week per expert and four sessions per week with two experts.

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II - 4 - STAGES OF DEVELOPMENT.

The plan has been divided into three development phases :

- the first two phases are concerned more particularl with the expert system part.

- the first dealt with defining the software architecture of the system through the existing acquisition struct as well as defining the information to be acquired for processing.

- the second involves analysing the problem or a sample set of the crane's functions (one of its movements w chosen). Then an unconnected prototype is made validating the approach which has been chosen and allowing a method of analysis to be set up which can be used for the next step by expanding it to other functions. The last phase (and the longest) consists of connecting up the prototype, then expanding it out and finally developing the aspects more concerned with maintenance management (if necessary, imparallel).

This incremental approach enables tangible progress markers to be established in order to appreciate the advantages and the quality of the system, hence to follow the evolution of the plan more closely white ot the same time permitting gradual financing.

III - CONCLUSION.

In the light of our experience, certain conclusions can be dranwn about the way to tackle this type of plan.

When faced with a complex industrial problem :

- in a potentially dynamic context
- for which strategic goals have been fixed
- and which, naturally, corresponds to an economic necessity

computer technology can be envisaged as a solution.

And, if the problem calls for specific knowledge which is difficult to encode digitally.

- then, expert systems come to mind.

To have a chance of succeding, it is imperative to acquire a good knowledge of the problem area and also of expert system capabilities.

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Next the siutability of the processing technique (AI) with regard to the problem must be determined.

Finally, a development structure must be set up which encompasses the functions required to carry through the plan :

- a plan manager
- a computer engineer
- experts (techniciens and scientists)
- a methodologist
- a psychologist

To ovoid wasting time, it is not necessary to go back through the archives, but rather to select and make use of the most up-to-date scientific and methodological experiences :

- physical system modelling techniques
- knowledge representation
- systemic approach

etc....

The architecture of the final system slould be reviewed globally. It should make proper allowances for traditional and AI techniques so as to offer optimum characteristics :

- maximum speed
- parameterable
- modulable
- expandable
- reproducible
- universal,

depending on the goals set.

As for the development tool, we chose one which has undisputed industrial references and which seems the most suited to our application. Furthermore, it enables us to apply the principles mentioned earlier.

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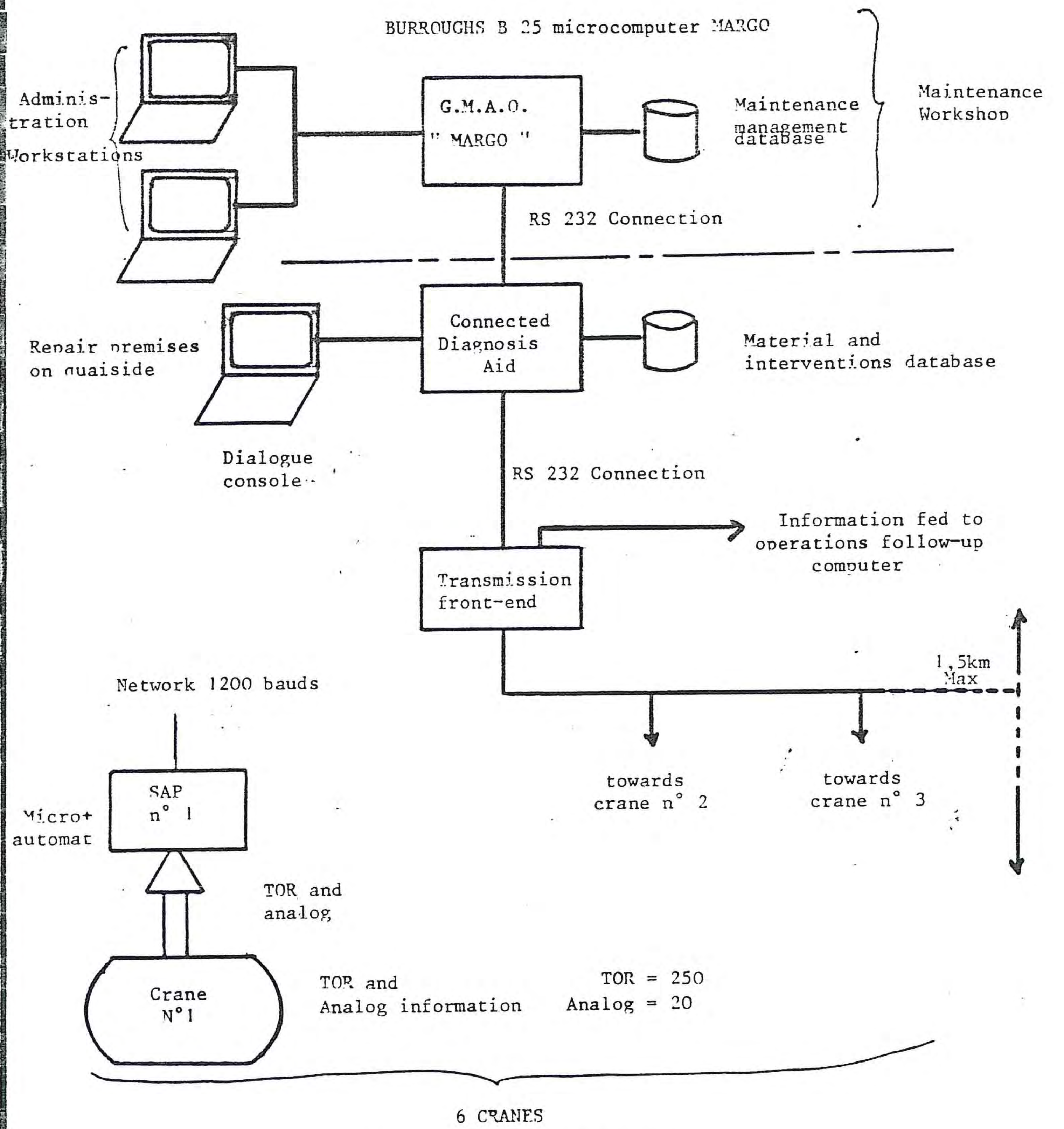
Well, those are a few general recommendations which are the result of our short experience.

- How is the plan progressing ?
    - The structure is in place.
    - The problem has been identified and its functionalities defined.
    - The working model of the system has been completed.
    - The knowledge-collecting phase is well under w
    - The knowledge compilation has still to be carr out.
    - The architecture of the system is taking shape

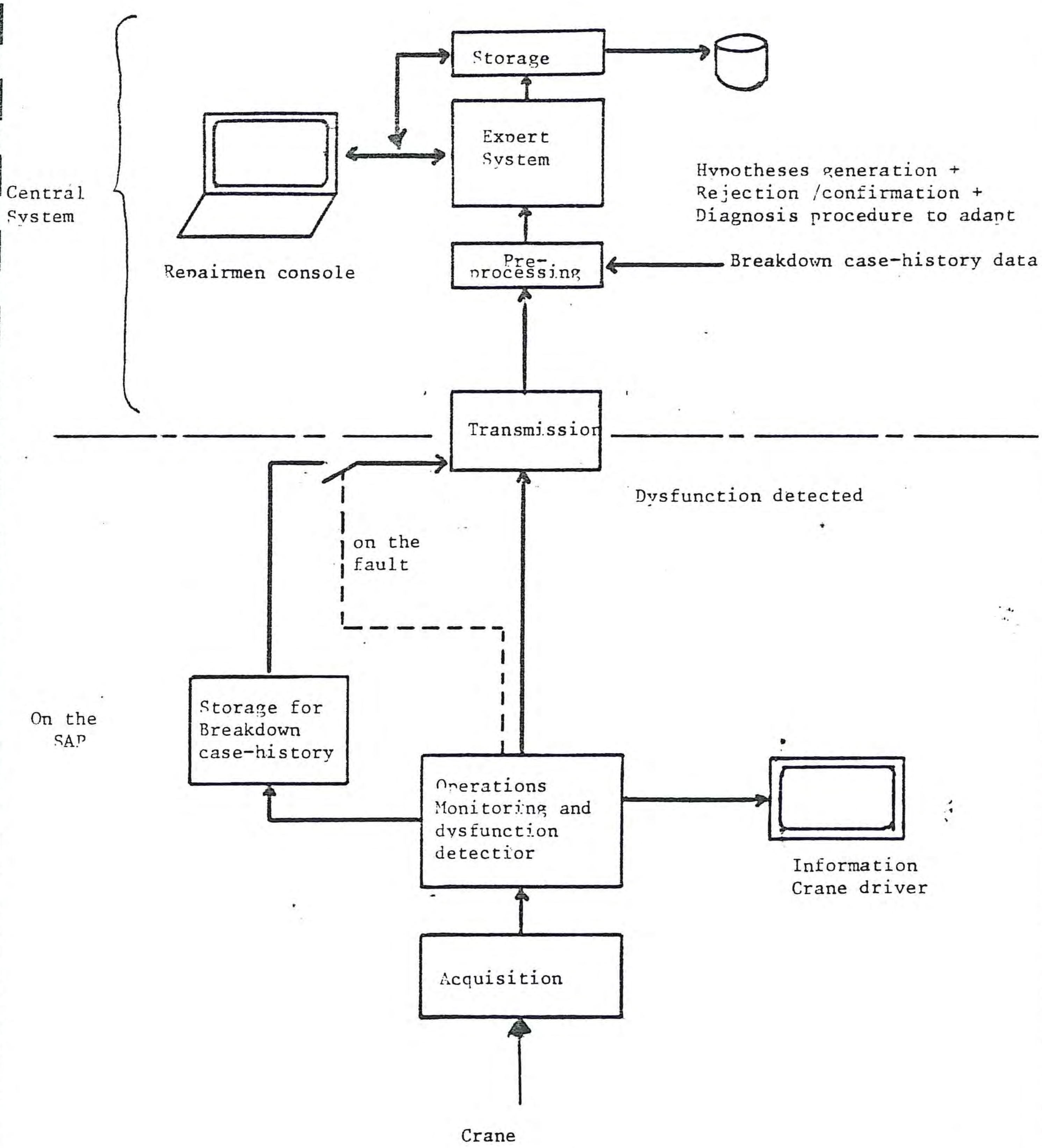
Although our final goal is still far four being reached , the results of our studies so far are wholly positive. A particularly good example is the setting up of an information exchange and training structure within the company. The experts (the techniciens) have had the opportun of updating their knowledge and of formalizing it. There ha abready been an increase in repair efficiency and technical improvements have been proposed. A real momentum is building up, which is of the greatest benefit to the actors, both the personnel and the company.

HARDWARE ARCHITECTURE



SAP : Parameter Acquisition System
GMAO : Computer Aided Maintenance Management
TOR : All or Nothing
THE SAP - Front-end network is fed by the H.T. cables on the cranes.

SOFTWARE ARCHITECTURE OF THE EXPERT SYSTEM PART



SOFTWARE INTERCONNECTION OF THE DIAGNOSIS AID PART